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A Context-Adaptive Content Ecosystem Under Uncertainty (CONCERT)

Topic: Context- and Content-aware, Communication Networks (C3N)

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concert

Project start date: 1st January 2014

Outline

- Scientific background
- Key challenges and impact of the project
- Project consortium
- Main scientific results, dissemination and other output
- Sustainability/valorisation

Scientific Background

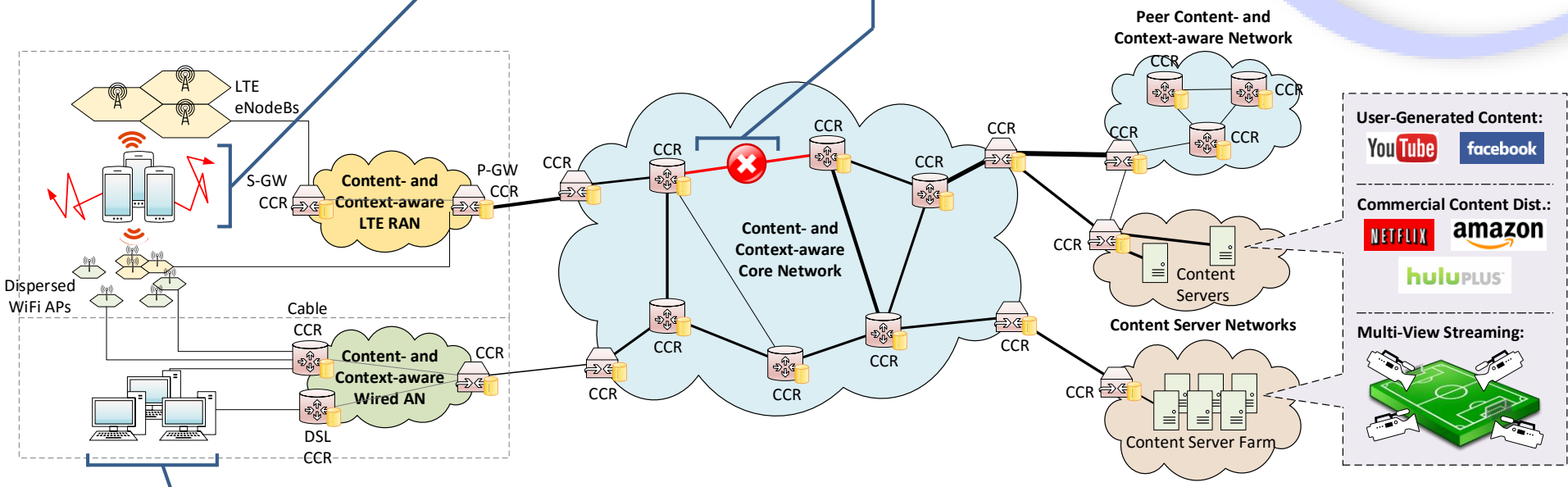
- Heterogeneity of content ecosystem
  - Increasing content volume and formats
  - Diverse user requirements
  - Dynamic and varied network capabilities and operating conditions
  - Increasing number of connected devices with different constraints
  - Emerging service and applications
- Internet **NOT** designed to operate in such conditions and for such purposes.

Overall objective: to devise and evaluate a context-aware content ecosystem to holistically manage and exploit uncertainties in future, dynamic, content-oriented network environments.

- This ecosystem will be based on information-centric networking (ICN).
  - Centered on information (*what*) instead of host locations (*where*)
  - Content-based resolution and delivery based on names
  - Support intrinsic in-network content manipulation (data caching/storage and processing)

Scientific Background

Threats:
Network anomalies disrupting content service performance



Requirements:
Heterogeneous and changing service requirements by end users

Opportunities:
Exploitation of opportunities for cost reduction or performance enhancements

Project Impact

- Collaborations between ICN/networking and multimedia communication research communities
- Theoretical
  - Development of learning strategies for adaptive resource allocation in networks
  - Design of methods for modelling information diffusion in networks in general
- Multimedia and ICN Communications:
  - Development of ICN-based in-network mechanisms with context-awareness
  - Design of adaptive and interactive multimedia systems
  - Development of cost-effective streaming solutions in heterogeneous user populations
  - Multimedia services in ICN networks

Project Consortium

Project Commencement: **1st January 2014**

Project Duration: **3 years + 1 year extension**

Partners	Country	Sponsor
Project Coordinator University College London (UCL) • George Pavlou, Truong Khoa Phan	UK	EPSRC
University of Surrey (UniS) • Ning Wang, George Kamel	UK	EPSRC
AAU Klagenfurt (AAU) • Hermann Hellwagner, Benjamin Rainer, Daniel Posch, Sebastian Theuermann	Austria	FWF
École Polytechnique Fédérale de Lausanne (EPFL) • Pascal Frossard, Stefano D'Aronco	Switzerland	SNSF

Main Scientific Results

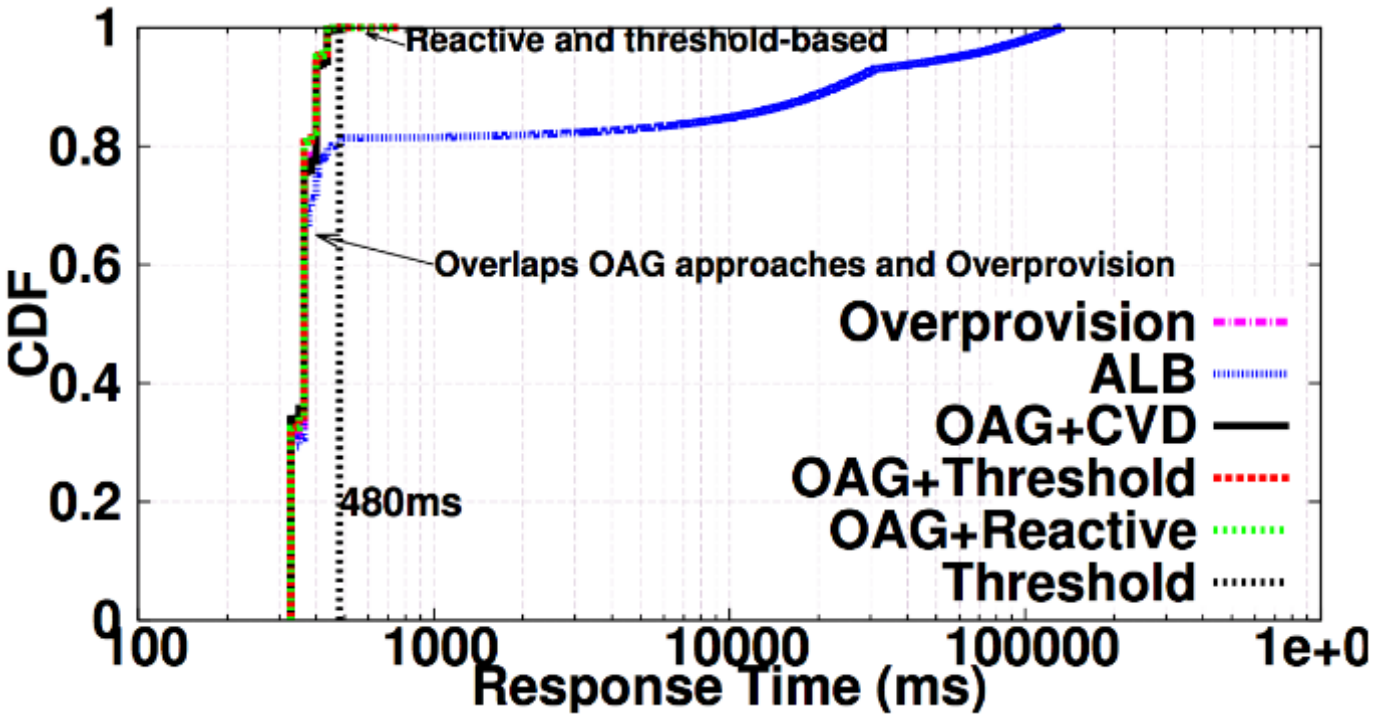
- Network function virtualization (NFV) and mobile edge-cloud (MEC) based scheme to bring resources closer to users (Cloudnet 2016).
- Logic-based declarative knowledge representation and stream reasoning approach (extension to Answer Set Programming, ASP) to model an “Intelligent Caching Agent” in CCN/NDN quite successful (feasibility study). Publications at an AI conf. (JELIA 2016) and a networking conference (ICC 2017).
- Extension of Stochastic Adaptive Forwarding (SAF) in NDN by context awareness (SAF-Context-Aware Adaptation, SAF-CAA). Publication as inaugural “replicatable paper” in ACM CCR.
- Price-Based Quality-Aware HAS.
- Low Delay Congestion Control.

Main Scientific Results (cont'd)

- Context-Aware Representations for MV Adaptive Streaming.
- Context-aware 4K video delivery techniques for LTE-A environments
- Test Bed Implementation of Context-Aware Video Streaming over ICN

Low Latency Application with NFV/MEC

- Placement optimization is NP-hard problem, we propose adaptive greedy heuristic algorithm
- Take into account auto-scaling and load balancing

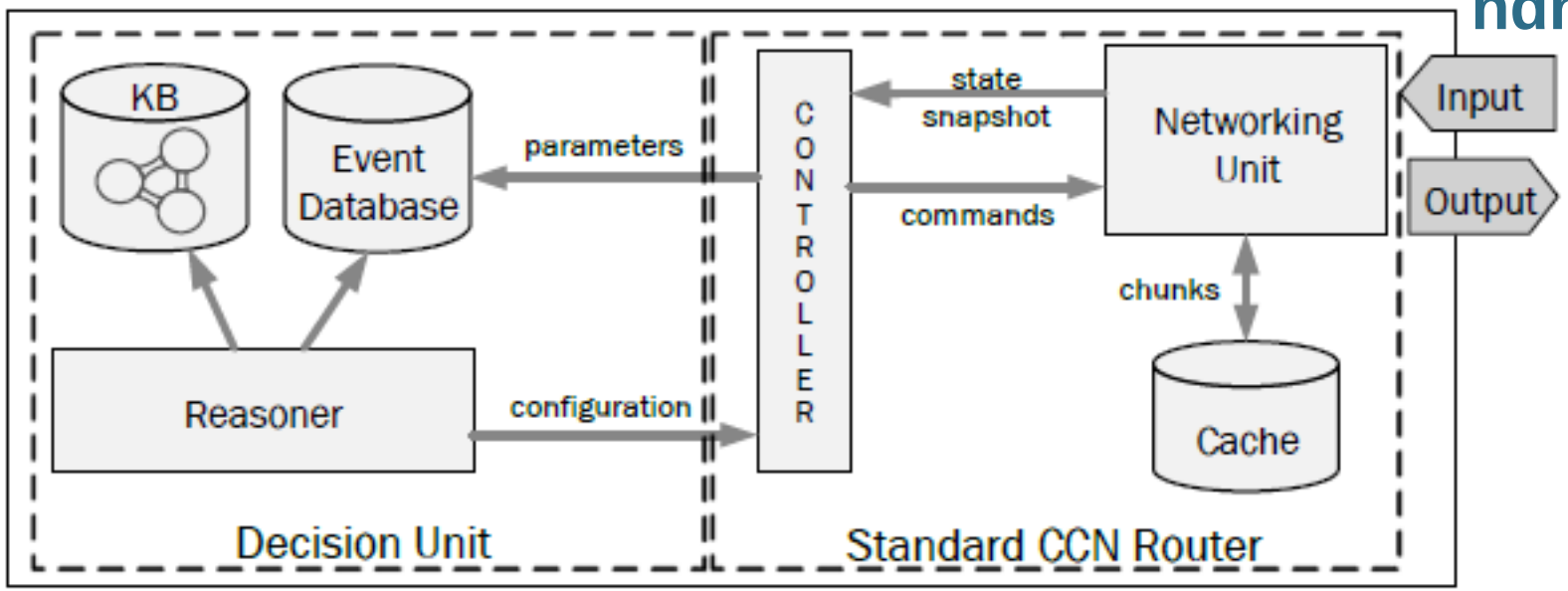


“Intelligent Caching Agent (ICA)“

ICA (local on each CCN/NDN router) …

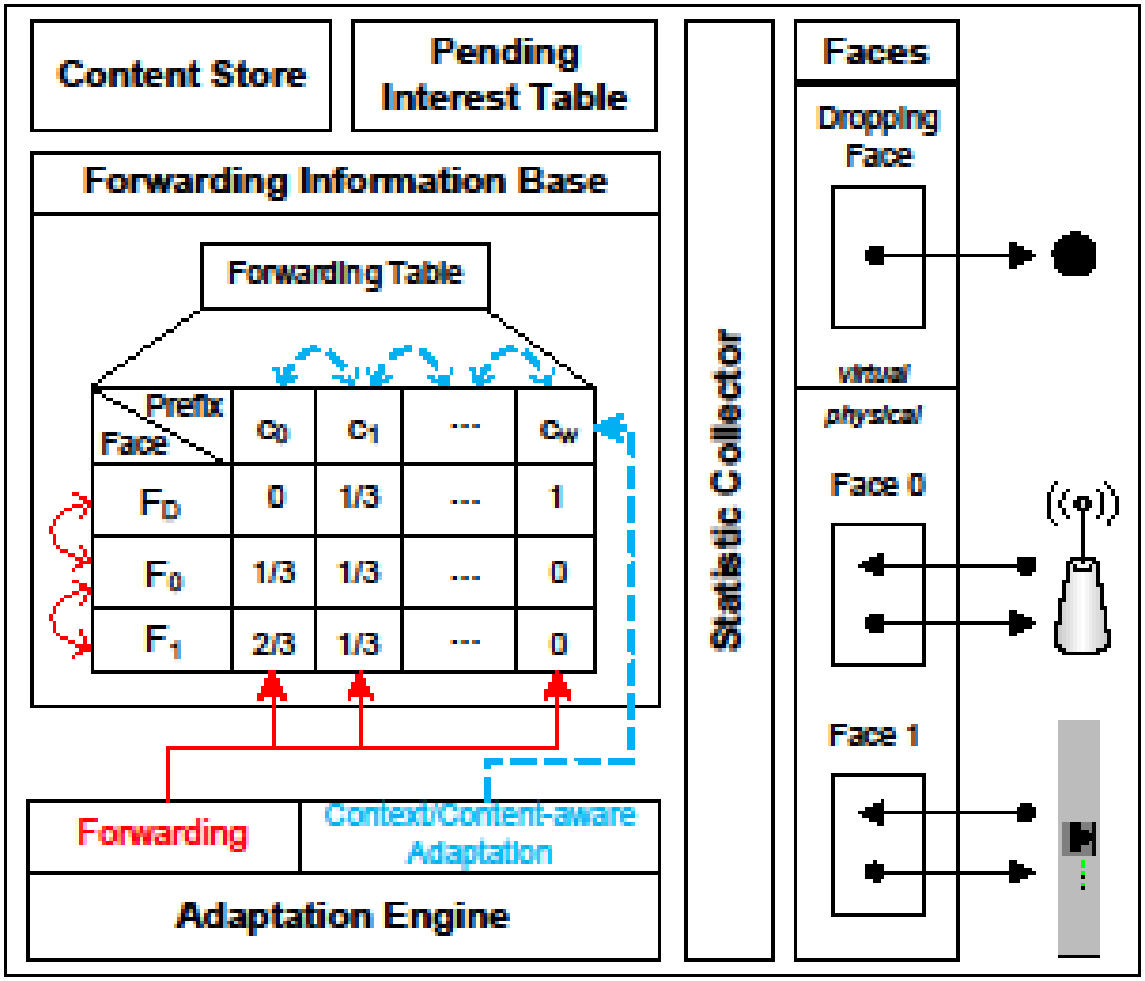
- … controls local caching strategy (actually, cache replacement strategy) using stream reasoning
- … extends standard CCN/NDN router by a decision unit

LARS **ndnSIM**



SAF-Context-Aware Adaptation

- SAF-CAA leads to significant QoS improvements in NDN due to enhanced forwarding decisions
- Redirects or prioritises flows
- Shown for diff. applications (video streaming, VoIP, FTP)



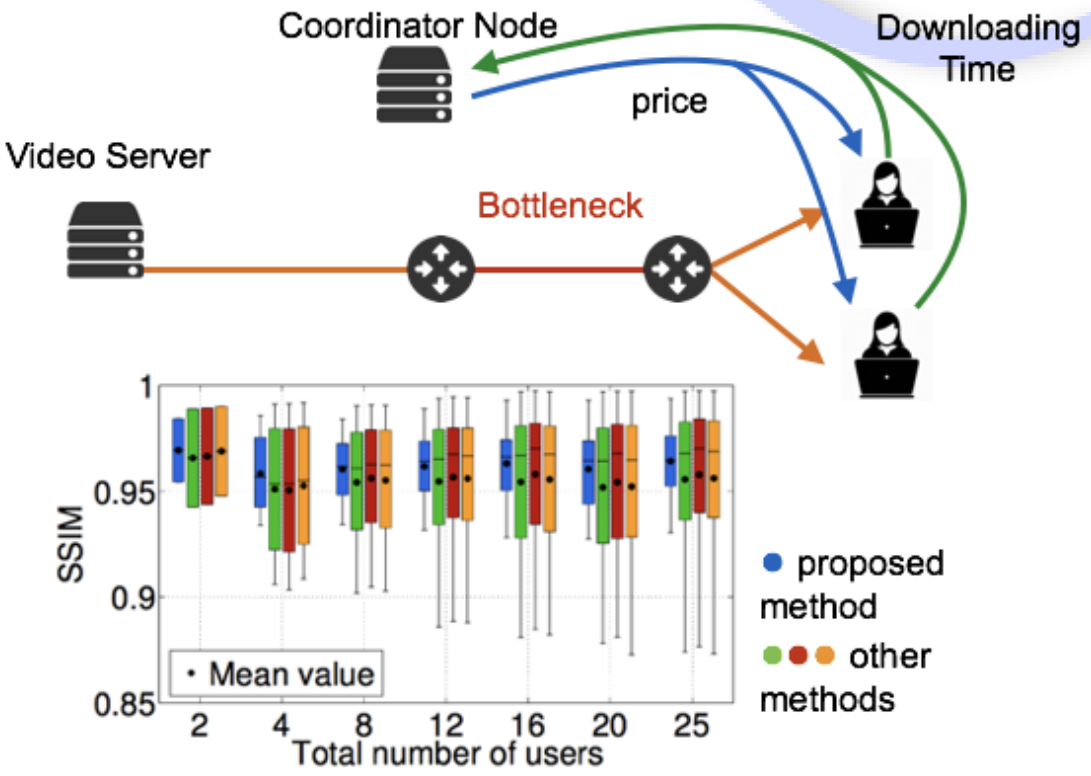
Price-Based Quality-Aware HAS

- **Equal Downloading Rate** (conventional HTTP adaptive streaming) ⇏ **Maximum Delivered Quality**

GOAL: optimize the video quality among users in a HAS system.

Proposed Solution:

- Single bottleneck link
- Distributed Price-based algorithm + Coordinator node
- NO per-user state
- NO prior knowledge of the bottleneck capacity
- Resilient to Cross-Traffic



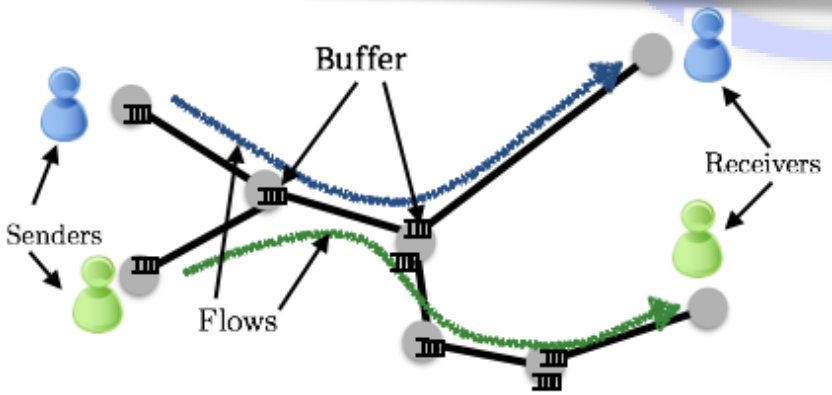
Low Delay Congestion Control

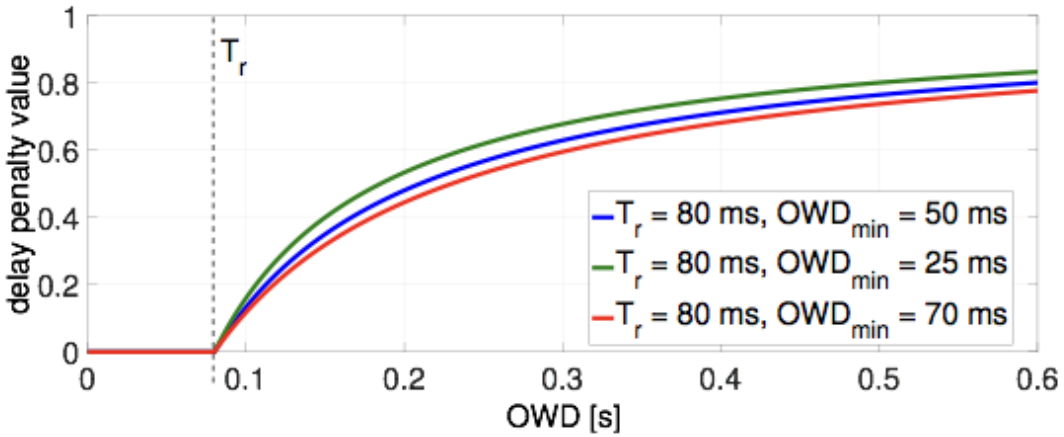
MOTIVATION: A robust congestion control for delay sensitive multimedia applications is fundamental for providing a good QoS to the users

GOAL: attain a low delay communication when possible, and not starve when competing with loss-based flows.

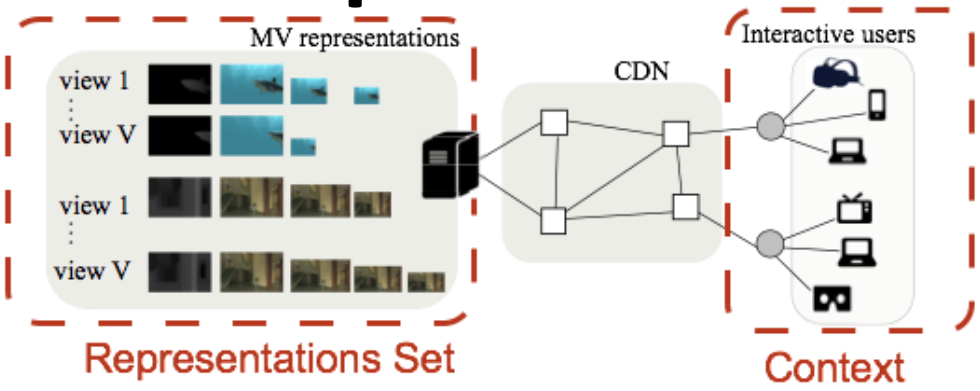
Proposed Solution:

- adjust sending rate according to one way delay (OWD) when experienced delay is low
- discount delay measurements for large delays (avoids starvations against loss-based flows)





Context-Aware Representations for MV Adaptive Streaming

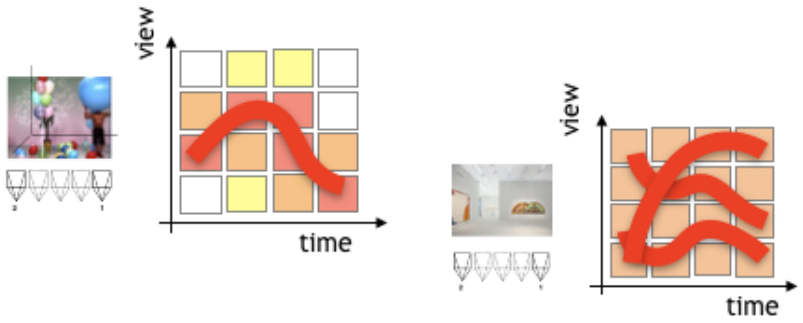


GOAL

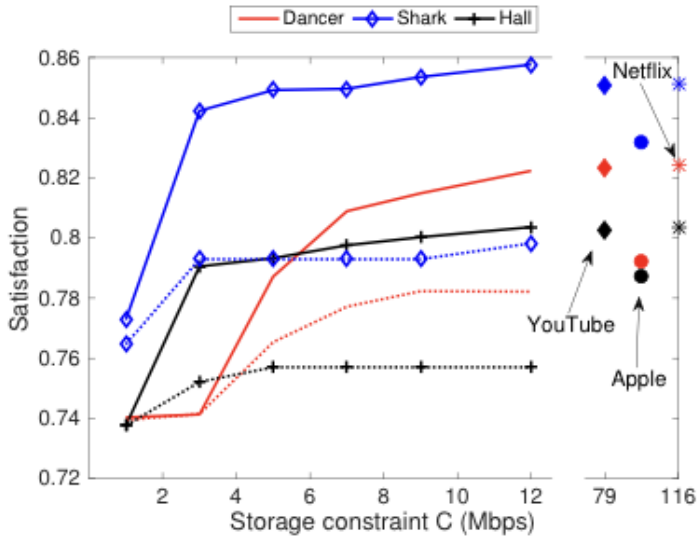
How to **optimally adapt the representations** set to the perceived **context of interactive users**?

CONTEXT

- different content characteristics
- heterogenous rendering distortion
- different interactivity levels

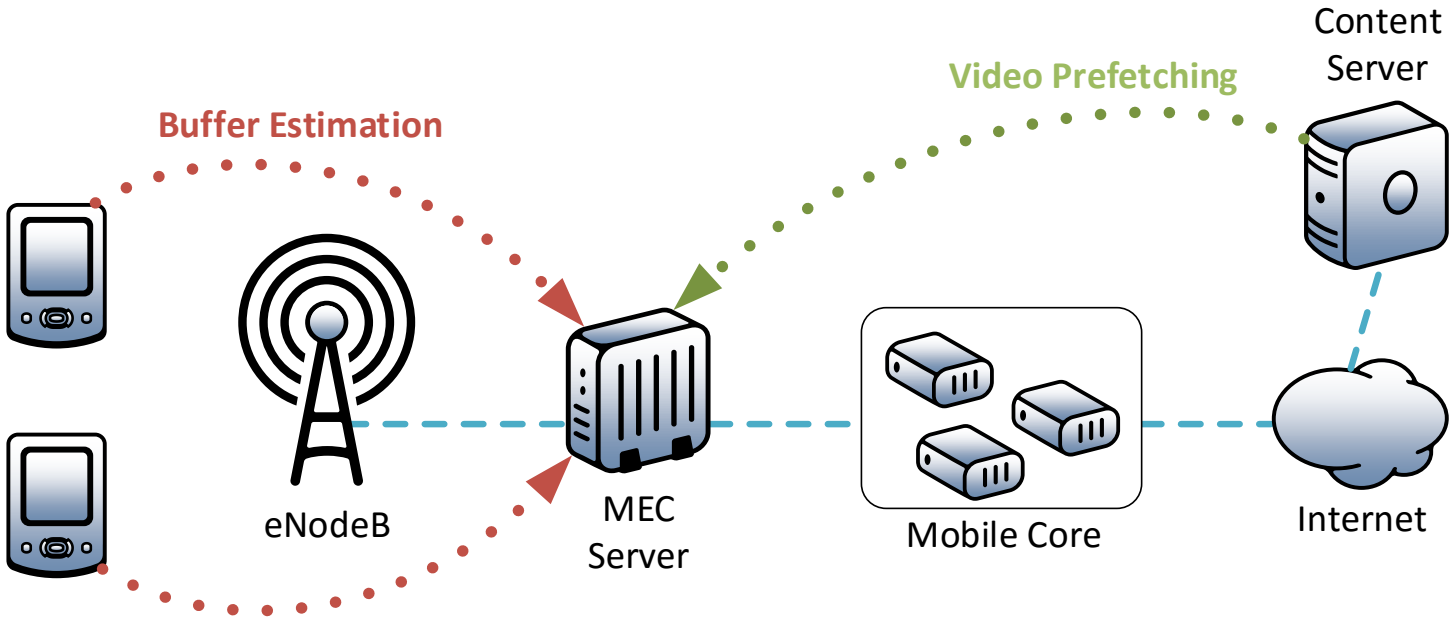


RESULTS



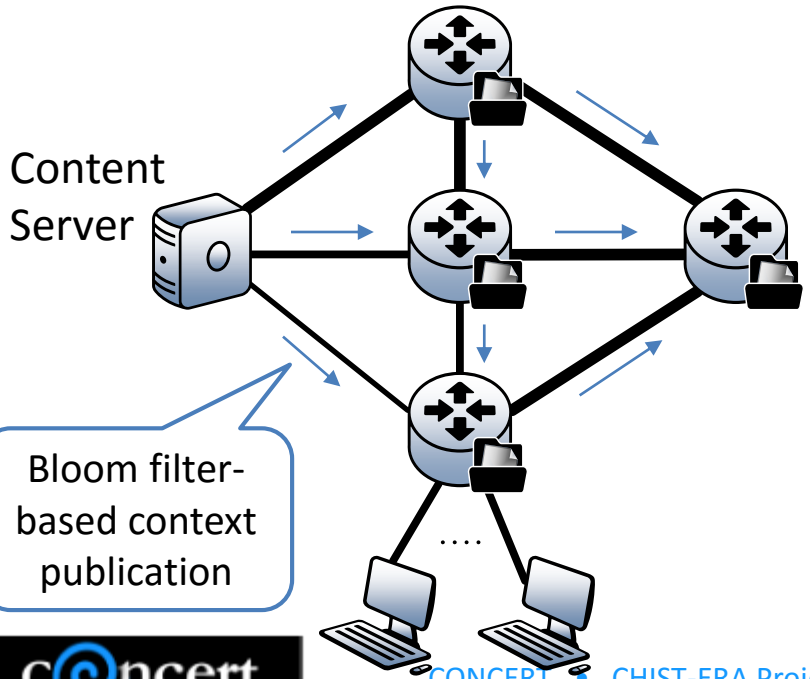
Context-Aware 4K Video Delivery Techniques for LTE-A Environments

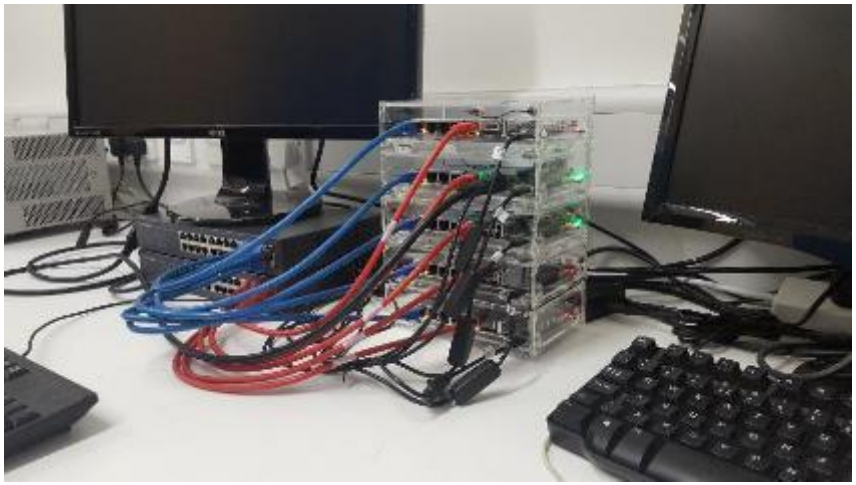
- Estimation by MEC server of video buffer level of each attached user
- Prefetching of DASH video at mobile edge



Test Bed Implementation of Context-Aware Video Streaming over ICN

- Bloom filter based context-aware content publication and resolution
- Developed on top of NDN's NFD within a test bed of low cost Banana Pi routers





Dissemination

- Scientific Publications
  - This year: 10 journal papers; 11 conference papers
  - Overall: 16 journal papers; 22 conference papers
- Deliverables
  - CONCERT consortium, “D2.2: Learning and Decision-Making Methodologies and Interim CONCERT Architecture and Framework”.
  - CONCERT consortium, “D3.1: Interim Specification of Context-Aware Content Adaptation”.
  - CONCERT consortium, “D4.1: Interim Specification of Context-Aware Network Adaptation”.
  - CONCERT consortium, “D5.1: Interim Specification of Cross-Layer and Cross-Player Adaptation Interactions -Algorithms and Modelling”.
  - CONCERT consortium, “D6.3: Year 3 Project Dissemination Report”.

Dissemination

- Workshop Organization
  - International **Workshop on Multimedia Streaming in Information-Centric Networks (MuSIC 2017)** at Hong Kong, 10th July 2017 in conjunction with IEEE ICME 2017.
- Miscellaneous
  - CONCERT at http://www.concert-project.org

Sustainability/Valorisation

- Foster collaborations and interactions between ICN/networking and multimedia communication research communities
  - Workshops: http://music2015.itec.aau.at/, http://music2016.itec.aau.at/, and http://music2017.itec.aau.at/
- Open access to AAU ICN research (results)
  - Publicly available at http://icn.itec.aau.at
- Other developed software made (or to be made) available online

Thank you

www.concert-project.org